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Design and Implementation of Dual Clutch Transmission

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Abstract: Dual clutch transmissions (DCTs) refer to the double friction clutches; in the vehicle shift gearbox they are designed and fully automated.The greatest advantage of the DCTs is the fuel economy boost as the power transfer from the engine to the transmission, always has a very high coefficient of friction and is not disturbed.Similar to the traditional six-speed automatic gearbox, the new six-speed DCTs will provide more than 10 per cent improved fuel economy.This paper describes three types of vehicles: conventional dual-clutch transmission (DCT); conventional hybrid electric vehicle (HEV); dual-clutch hybrid (HDCT). They're simulated on various drive-cycles.HEV and HDCT demonstrated superiority on low-speed fuel savings. Due to the higher performance of clutches to torque converters, HDCT displays a little bit higher energy saving over HEV. Conclusions and recommendations are also provided for enhancing DCT, HEV, and HDCT.Higher energy efficiency than automatic transmission systems with torque converters and the ability to fill the torque gap during gear shifts to allow seamless longitudinal acceleration profiles are the main advantages of double clutch transmissions (DCTs).

Keywords: Battery, Dual Clutch Transmission (DCT),HDCT,HEV, Torque Converters.

INTRODUCTION

Dual clutch transmission (DCT) is an automatic transmission system which uses two separate clutches. New technologies with materials, sophisticated electronics, hydraulics, and computer controls allow those clutches and gearshifts to quickly engage in automatic power transmission.The use of dual clutches gives greater cost and energy efficiency effectiveness over the use of torque converters[1].DCT allows for fast gear commitments without interrupting low cost, higher efficiency, power transfers, and environmental changes as there is no frequent discharging of oil like in torque converters.Dual clutches for new automatic transmission vehicles are being increasingly researched and built in Volkswagen, Ford and Hyundai[2]. Nevertheless, most DCTs are only initial concept designs, due to the extremely sophisticated control systems.DCT is not a new technology and although DCT offers higher transmission performance, DCT manufacture is more complicated and more costly than using automatic torque converter gearboxes.Hybrid dual clutch transition (HDCT) as the combination of hybrid electric vehicle (HEV) and DCT becomes a new concept vehicle and its performance will be fully investigated in this article.The engagement of the clutches is automated by computers and actuators and occurs for just a few milliseconds. DCT is expensive and complex[3]. The drivers thought that the engagement of the gear is not as smooth as they expected on some DCT vehicles.Another downside of DCT is the use of wet clutches, and it is necessary to change the transmission oil more often than in an automatic torque converter. As a result, the DCT becomes more expensive than the torque converter gearbox, and is mostly used in sports cars[4].

1. *HEV Modelling:*

This consists of 2 electric motors EM1 and EM2 and an ICE. EM1 is small and serves as the starter from ICE/battery generator. EM2 is a powerful motor and serves as a low-speed and low-torque vehicle propeller.EM1 triggers ICE to move the vehicle at a higher speed and a higher torque, while EM2 turns off. Where appropriate, EM1 turns on as a generator to

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charge the battery.EM1, EM2 and ICE come together to power the vehicle in some extremely high torque demands. This HEV model is illustrated in figure 1[5].

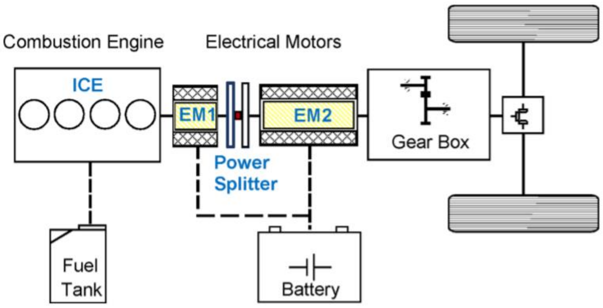

Figure 1: Configuration of a HEV Model

Figure 2 shows the full HEV model in MATLAB. Power split unit interconnects with engine, motor, vehicle dynamics. The input of vehicle speed control is the demands of speed [6].In fact, the demands for speed are in EU and US standard drive cycles. For each test it records and analyses the outputs of vehicle speeds, gear changes, fuel consumption, battery status, etc.

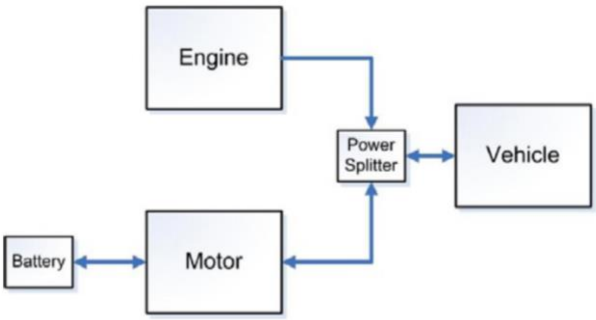

Figure 2: HEV Main Blocks

2. DCT Modelling:

DCT design which includes two independent clutches. Each clutch is connected to a series of unusual and even gears. Clutch 1 trigger the odd gears in this DCT and the even gears are from clutch 2.The modern electronics and computer controls require instant change of clutches and gears, based on the demands of speed and torque.Hence, the DCT provides higher energy efficiency, quick engagement and environmental benefits than those in torque converters[7].

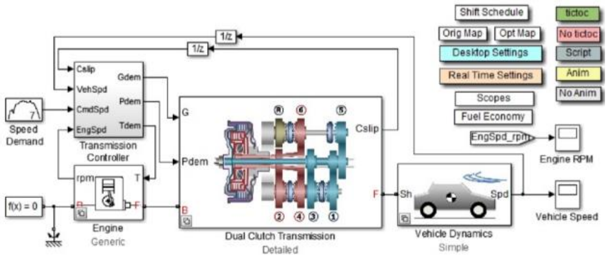

Figure 3: DCT Full Systems

3. HDCT Modelling:

A new model of HDCT is conceived as shown in Figure 4. This model uses the previous HEV with a new DCT added for gear change by computer control determined from the required output torque and speed specifications[8].

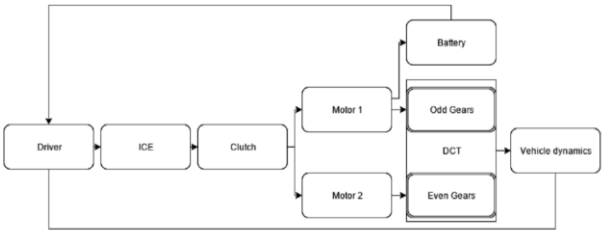

Figure 4: HDCT Scheme

As with the DCT car, the HDCT vehicle is mounted on its gearbox with two different clutches. One clutch is attached to the odd gears and the other to the even gears.A full HDCT model is built in MATLAB Simulink as shown in figure 5. This model is used to simulate and the simulation results are analysed and compared to the HEV[8].

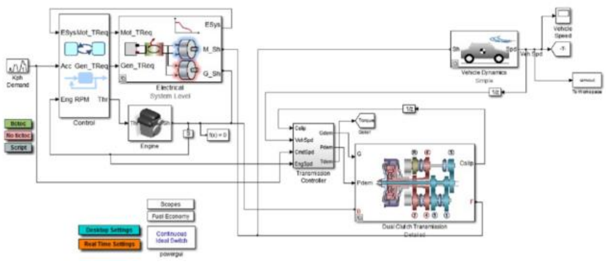

Figure 5: HDCT Full System

4. Vehicle System Modelling:

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Each segment introduces a forward-looking vehicle model considered in this work. Figure 6 displays the vehicle's bond graph layout with the DCT after locking of the transmission clutch.Though the model's structure changes slightly during the gear shifts, this causality is preserved. The subsystem models are selected from the literature, so they have enough fidelity to simulate fuel economy while being computationally efficient.The driver is designed as a proportional-integral (PI) controller that controls the throttle and brake signals. Modelling the engine as a source of power, it powers the transmission pump.The pump inputs engine speed (ωe), line pressure (P), and a part of engine torque (TP), and produces flow(Qa). Pump flows through the hydraulic load (RH). The remainder of the engine load torque is transferred through the activated clutch to the DCT.The output torque from the motor (To), is input to the final drive, and the final drive torque drives a vehicle layout of reduced point-masse. The road load (Rv), is calculated by taking into account aerodynamic drag, rolling resistance and the slope of the lane[9].

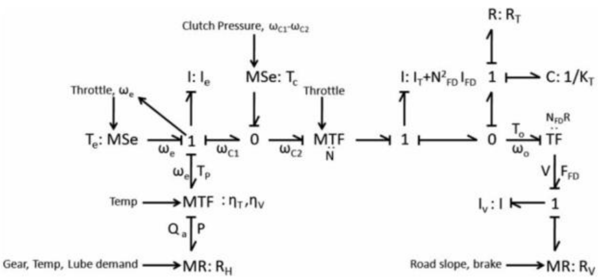

Figure 1: Bond Graph Model of the DCT Vehicle When the Clutch is locked

ASSUMPTIONS AND LIMITATIONS

Generally assumptions made during the modelling process are necessary to develop a computationally acceptable model. This includes ignoring temperature effects,backlash and treating clutches as Coulomb friction elements.The research may be hampered by other assumptions, made for the sake of expediency.Most writers neglect the synchronization cycle precisely because it occurs before the engagement with the clutch and is not important to manage.It is argued that this process is primarily correlated with the quality of the change, and hence greater research is required.All demonstrates the difficulty and uncertainty of synchronization, and that detailed understanding is necessary to ensure that the process is successful.The DCT being such a lightly damped system, the drag and other frictional losses are expected to play an important role in the damping of the system.The losses into the transmission lumps into the powertrain model as an output loss.Synchronization modelling is also affected by simplifying the losses, as it plays a key role in clutch interaction and locking processes.The system's hydraulic actuation uses pressure profiles against slip speed to simulate hydraulics[10].

CONCLUSION

The three DCT, HEV and HDCT vehicle models are developed and simulated in urban, extra-urban and highway environments. HEV and HDCT proved superior on low-speed fuel savings.HDCT shows much higher energy savings over HEV due to improved clutch performance to torque converters.Due to the complexity of the control system the output of DCTs is increasing moderately but still limited.There is no significant difference in fuel consumption between HDCT and HEV on the FHB7 motorway driving loop.The losses into the transmission lumps into the powertrain model as an output loss.Synchronization modelling is also affected by simplifying the losses, as it plays a key role in clutch interaction and locking processes.The driver is designed as a proportional-integral (PI) controller that controls the throttle and brake signals. Modelling the engine as a source of power, it powers the transmission pump.Dual clutches for new automatic transmission vehicles are being increasingly researched and built in Ford,Volkswagen, and Hyundai. Nevertheless, most DCTs are only initial concept designs, due to the extremely sophisticated control systems.HDCT's industrial applications have great potential as the rapid advance of new materials and technologies.

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